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STUDIES ON CHOICE OF PARENTS AND GENE ACTION IN RICE HYBRIDS INVOLVING YIELD AND PHYSIOLOGICAL TRAITS UNDER AEROBIC CONDITION

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ABSTRACT

Combining ability and heterosis was studied in 21 parents and 90 hybrids for yield and physiological traits under aerobic condition. Analysis of variance was highly significant for all the characters and predominantly controlled by non additive gene action. IR79128A (L_1), IR79156A (L_2), IR70369A (L_4), IR7925A-428-2-1-1R (T_{11}), KMP -148 (T_{12}) and BI-33 (T_{15}) were adjudged as the best combiners for most of the yield contributing characters. The hybrids IR70369A / IR 7925A-428-2-1-1R, IR 79128A / BR -2655, IR70369A /KMP-105 and IR 79128A / KMP -149 were found to have specific combiners for most of the yield contributing and drought tolerant traits including single plant yield.

KEYWORDS: Aerobic Rice, General Combining Ability, Specific Combining Ability, Non Additive Gene Action

INTRODUCTION

Rice is the staple food for over 70 per cent of Asians, the majority of whom are living below the poverty line. More than 90 per cent of the world's rice is produced and consumed in Asia (Barker *et al.,* 1999) and rice production must be increased by an estimated 56 per cent over the next 30 years to keep up with population growth and income-induced demand for food in most Asian countries where about 75 per cent of total rice production comes from irrigated lowlands (Maclean *et al.,* 2002). More irrigated land is devoted to rice than to any other crop.

With the growing population, increased urbanization and environmental degradation, the supply of fresh water for all human activities is depleting and the situation is getting rapidly worse. There is a need to genetically alter the basic water requirements of rice through breeding techniques (Vijayakumar *et al*., 2006). Various field techniques to save irrigation water have been explored. Aerobic rice is one such option to decrease water requirements in rice production. Therefore, it is essential to understand the effects of the prevailing drought stress in the target environment on both yield and drought tolerant traits in order to undertake the genetic improvement of aerobic rice in this region. Most of the traits are quantitative in nature; hence it is necessary to know the inheritance of these traits. The success of plant breeding programme depends to a greater extent on the knowledge of the genetic architecture of the population and selection of appropriate breeding method for the improvement of traits of interest. It is essential to estimate the various types of gene action for the selection of appropriate breeding procedure to improve the quantitative and qualitative characters (Banumathy *et al*., 2003). Genetic information about the combining ability of parents and hybrids and nature of gene action involved in the inheritance of a trait would be of immense value to plant breeders in the choice of parents and to identify potential crosses of practical use.

Hybrid rice technology had also shown increased yield, farmer profitability and better adaptability to stress environments such as water scarce and aerobic conditions. Development of rice hybrids with high yield potential for

aerobic conditions would be one of the exciting researches to be carried out to overcome the existing water crisis in India. Breeding strategies based on selection of hybrids require expected level of heterosis as well as the specific combining ability. In breeding high yielding varieties of crop plants, the breeders often face with the problems of selecting parents and crosses. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parents and crosses for the exploitation of heterosis.

The Line x Tester analysis provides information about general combining ability (*gca*) of parents and specific combining ability (*sca*) effects of crosses and is helpful in estimating various types of gene actions. The main objectives of this study were to evaluate the rice hybrids along with their parents under aerobic condition and to determine the GCA and SCA of different genotypes to find the best general combiner and hybrid for yield and physiological traits.

MATERIALS AND METHODS

Six Lines and 15 Testers were subjected to crossing by 'Line x Tester' mating design (Kempthorne, 1957). Ninety hybrids along with six lines, 15 testers and one check were evaluated under non-puddled and non flooded aerobic soil, during Rabi, 2010.

The hybrids along with their parents were maintained under irrigated condition upto 55 days. From the 56th day onwards the treatment plot was maintained under aerobic condition. For every irrigation thereafter, soil sampling was carried out before and after irrigation to assess the soil moisture content. Irrigation was given only when hair line crack was noticed in the treatment plot and the control plot was maintained under normal flooded condition till maturity.

Observations were recorded for the drought tolerant, yield and its component traits *viz*., Days to 50 per cent flowering (DF), Plant height (PH), Number of Productive tillers per plant (PT), Number of panicles per plant (PP), Panicle length (PL), Filled grains per panicle (FG), Spikelet fertility (SF), Hundred grain weight (HGW), Proline content (PC), SPAD chlorophyll meter reading (SCMR), Chlorophyll stability index (CSI), Relative water content (RWC), Biomass yield (BMY), Dry shoot weight (DSW), Dry root weight (DRW), Root / shoot ratio (RS), Root length (RL), Harvest index (HI), Single plant yield (YLD) under water stress and fully irrigated (control) conditions as per the Standard Evaluation System (1996).

The data on the hybrids and parents were subjected to L × T analysis. The assumption of null hypothesis was tested for differences among the genotypes as detailed by Panse and Sukhatme (1964). The general combining ability effects of the parents and specific combining ability effects of the crosses were worked out as suggested by Kempthorne (1957).

RESULTS AND DISCUSSIONS

The analysis of variance for combining ability indicated that the lines and testers differed significantly among themselves for all the traits under aerobic condition. Further, the analysis of GCA/SCA variances indicated that the nature of gene action was non additive due to dominance with non fixable genetic variation for all the characters studied (Table 1 and 2). A

Success in any breeding programme largely depends on the knowledge of the genetic architecture of the population handled by the breeder. The estimate of components of variance provides an idea about additive and non additive (dominant) types of gene action. The results are in accordance with the earlier reports of Ananda Kumar *et al.*

(2004). The presence of greater magnitude of non additive gene action offers scope for exploiting hybrid vigour through heterosis breeding and hence, these parents can be exploited for production of commercial hybrids. The proportional contribution to total genetic variance by the lines was found to be higher for 100 grain weight. For other characters contribution from line x tester interaction was higher. These results indicate the predominance of non additive gene action. Similar results were also reported by Malarvizhi *et al.* (2010).

Combining ability effect is one of the most important parameters commonly used by plant breeders to evaluate the genetic potential of the materials handled. Best parents selected based on *per se* performance need not always be the best combiners. IR79128A (L_1), IR70369A (L_4) and IR79156A (L_2) among lines and BI-33 (T_{15}), IR79582-21-2-2-1R (T_5), KMP-105 (T_{11}), T_1 (IR 69726-29-1-2-2R) and MAS- 946-1 (T_9) among testers were found to be the best general combiners, since they exhibited high *gca* effects for majority of the traits including drought tolerant and yield characters (Table 3). High *gca* effects show presence of favorable genes with additive type of gene action. Therefore, a multiple crossing programme involving good general combiners isolated in the present study is recommended to identify superior genotypes as suggested by Nadarajan and Gunasekaran (2005).

The specific combining ability effects could be related with hybrid vigour and signifies the role of non-additive gene action in character expression (Sprague and Tatum, 1942). High *sca* effects showed predominance of non-additive gene effects mainly dominance gene effects (Nadarajan and Gunasekaran, 2005). In the present investigation, negative *sca* effects were taken into consideration for days to 50% flowering and plant height while for other traits, positive *sca* effects were considered. The hybrids IR70369A / IR 7925A-428-2-1-1R, IR 79128A / BR -2655, IR70369A /KMP-105 and IR 79128A / KMP -149 were found to have specific combiners for most of the yield contributing and drought tolerant traits including single plant yield as earlier reported by Panwar (2005).

CONCLUSIONS

Genetic variability studies provide basic information regarding the genetic properties of the population based on which breeding methods are formulated for further improvement of the crop. Considering the fact that Heritability gives the information on the magnitude of inheritance of quantitative traits, while genetic advance will be helpful in formulating suitable selection procedures based on the above results the traits reflecting high heritability with high genetic advance can be given importance while selection and the genotypes that are showing these results can utilized in the further crop improvement programme. It is essential to estimate the various types of gene action for the selection of appropriate breeding procedure to improve the quantitative and qualitative characters Genetic information about the combining ability of parents and hybrids and nature of gene action involved in the inheritance of a trait would be of immense value to plant breeders in the choice of parents and to identify potential crosses of practical use.

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APPENDICES

Table 1: Analysis of Variance for Combining Ability for Different Biometrical Traits in Parents and Hybrids

Source of Variation	DF	Mean squares									
		Days to 50 Per Cent Flowering	Plant Height	Productive Tillers Per Plant	Panicles Per Plant	Panicle Length	Spikelet Fertility	Filled Grains Per Panicle	Hundred Grain Weight	Harvest Index	Single Plant Yield
Replication	1	3.563	0.0393	0.054	0.0001	0.068	4.059	1.605	0.002	0.001	2.01
Hybrids	89	45.840**	60.724**	6.757**	11.692**	2.126**	40.081**	1257.936**	0.336**	0.01**	84.60**
Lines	5	116.875**	112.597**	8.287**	55.170**	4.156**	19.016**	1919.817**	3.216**	0.02**	11.18**
Testers	14	30.490**	51.784**	5.032**	7.494**	1.089**	63.989**	877.262**	0.102**	0.01**	145.82**
Line x Tester interaction	70	43.836**	58.808**	6.992**	9.426**	2.189**	36.804**	1286.794**	0.177**	0.01**	77.40**
Error	89	23.984	2.425	0.115	0.081	1.572	2.370	9.411	0.052	0.010	5.140

** Significant at 1% level

Table 2: Analysis of Variance for Combining Ability for Different Physiological Traits in Parents and Hybrids

Source of Variation	Df	Mean squares								
		Proline Content	SPAD Chlorophyll Meter Reading	Chlorophyll Stability Index	Relative Water Content	Biomass Yield	Dry Root Weight	Dry Shoot Weight	Root : Shoot Ratio	Root Length
Replication	1	0.59	1.23	1.15	0.01	15.15	0.01	2.89	0.001	0.001
Hybrids	89	95.78**	31.41**	339.80**	144.13**	51.48**	1.68**	9.06**	0.007**	0.002**
Lines	5	22.34**	54.21**	877.14**	496.14**	26.66**	15.88**	28.09**	0.04**	0.005**
Testers	14	191.09**	38.85**	285.14**	71.35**	71.35**	0.78**	7.21**	0.005**	0.002**
Line x Tester interaction	70	81.97**	28.29**	312.35**	133.54**	49.28**	0.85**	8.07**	0.004**	0.002**
Error	89	0.620	0.527	0.634	0.530	5.400	0.260	5.840	0.003	0.001

** Significant at 1% level

Table 3: Best Parents based on *Per Se* Performance and *gca* effects Under Aerobic Condition

S. No	Characters	*Gca* Effects			
1	**Days to 50 Per Cent Flowering**	CO MS 24A (L_6)	**11.**	**Proline Content**	IR70369A (L_4), CO MS 24A (L_6), IR 81178-2T-2-2-3R (T_2), IR 79582-21-2-2-1R (T_5), IR05 N496R (T_8), MAS- 946-1(T_9), KMP-105 (T_{11}), BR -2655 (T_{14}), BI-33 (T_{15})
2	**Plant Height**	IR79156A (L_2), IR73328A (L_3), IR70369A (L_4), IR 69726-29-1-2-2R (T_1), MAS -26 (T_{10}), KMP-105 (T_{11}), KMP -148 (T_{12}), KMP -149 (T_{13})	**12.**	**SPAD Chlorophyll meter reading**	IR 79128[a] (L_1), IR73328A (L_3), IR 69726-29-1-2-2R (T_1), IR 7925A-428-2-1-1R (T_4), IR 79200-45-2-2-1R (T_6), MAS-946-1(T_9), KMP -148 (T_{12}), BR -2655 (T_{14}), BI-33 (T_{15})

Table 3: Contd.,					
3	**Productive Tillers Per Plant**	IR 79128A (L_1), CO MS- 14A (L_5), IR 69726-29-1-2-2R (T_1), IR 81178-2T-2-2-3R (T_2), IR 79200-45-2-2-1R (T_6), IR05 N496R (T_8), KMP-105 (T_{11}), KMP -149 (T_{13})	**13.**	**Chlorophyll Stability Index**	IR 79128A (L_1), IR70369A (L_4), IR 69726-29-1-2-2R (T_1), IR 79582-21-2-2-1R (T_5), IR 79200-45-2-2-1R (T_6), IR 80402-88-3-1-3R (T_7), MAS- 946-1(T_9), KMP -149 (T_{13})
4	**Panicles per plant**	IR79156A (L_2), IR73328A (L_3), IR70369A (L_4), IR 80402-88-3-1-3R (T_7), MAS- 946-1 (T_9), MAS -26 (T_{10}), KMP-105 (T_{11}), KMP -148 (T_{12}), KMP -149 (T_{13}), BR -2655 (T_{14}), BI-33 (T_{15})	**14.**	**Relative Water Content**	IR79156A (L_2), IR73328A (L_3), IR70369A (L_4), IR 69726-29-1-2-2R (T_1), IR 81178-2T-2-2-3R (T_2), IR 80286-22-3-6-1R (T_3), IR 7925A-428-2-1-1R (T_4), IR 79582-21-2-2-1R (T_5), MAS -26 (T_{10}), KMP-105 (T_{11}), KMP -148 (T_{12}), BI-33 (T_{15})
5	**Panicle Length**	-	15.	**Biomass Yield**	CO MS- 14A (L_5), IR 80286-22-3-6-1R (T_3), IR 79582-21-2-2-1R (T_5), IR 79200-45-2-2-1R (T_6), MAS- 946-1 (T_9)
6	**Spikelet Fertility**	IR79156A (L_2), IR70369A (L_4), IR 7925A-428-2-1-1R (T_4), IR05 N496R (T_8), MAS -26 (T_{10}), KMP -149 (T_{13}), BR -2655 (T_{14}), BI-33 (T_{15})	16.	**Dry Root Weight**	IR 79128A (L_1), IR79156A (L_2), IR 80286-22-3-6-1R (T_3)
7	**Filled Grains Per Panicle**	IR 79128A (L_1), CO MS- 14A (L_5), IR 7925A-428-2-1-1R (T_4), IR 79582-21-2-2-1R (T_5), IR 79200-45-2-2-1R (T_6), IR05 N496R (T_8), MAS -26 (T_{10}), KMP-105 (T_{11}), KMP -148 (T_{12}), BI-33 (T_{15})	17.	**Dry shoot Weight**	IR 79128A (L_1), IR 79582-21-2-2-1R (T_5)
8	**Hundred grain weight**	IR73328A (L_3), IR70369A (L_4), CO MS- 14A (L_5), IR 69726-29-1-2-2R (T_1), MAS- 946-1 (T_9)	18.	**Root : Shoot ratio**	IR 79128A (L_1), IR79156A (L_2)
1.	**Harvest index**	IR79156A (L_2), CO MS 24A (L_6), IR 7925A-428-2-1-1R (T_4), IR 79582-21-2-2-1R (T_5), IR 80402-88-3-1-3R (T_7), IR05 N496R (T_8), BR -2655 (T_{14}), BI-33 (T_{15})	19.	**Root length**	IR 79128A (L_1), IR70369A (L_4), CO MS- 14A (L_5), IR 69726-29-1-2-2R (T_1), IR 81178-2T-2-2-3R (T_2), IR 80286-22-3-6-1R (T_3), MAS- 946-1(T_9), BI-33(T_{15})
2.	**Single plant yield**	CO MS- 14A (L_5), IR 81178-2T-2-2-3R (T_2), IR 79582-21-2-2-1R (T_5), IR05 N496R (T_8), KMP-105 (T_{11}), BR -2655 (T_{14}), BI-33 (T_{15})	**Overall effect**		IR 79128A (L_1), IR79156A (L_2), IR70369A (L_4), IR 79582-21-2-2-1R (T_5), MAS- 946-1 (T_9), KMP-105 (T_{11}), BI-33(T_{15})